## REMARKS

**Status of the claims:**

With the above amendments, claim 1 has been amended. Claims 1-4 are pending and ready for further action on the merits. No new matter has been added by way of the above amendments. Support for the amendment to claim 1 can be found at page 40, lines 6 to 9, page 40, line 25 to page 41, line 2, and at page 41, lines 5-16 of the written description. Reconsideration is respectfully requested in light of the following remarks.

**Changes in the Written Description**

The written description has been amended so that the term "openings" appearing at page 63, line 11 has been amended to --rhombic openings--. This amendment is a correction of a mistranslation that occurred during the preparation of the English translation of the original Japanese PCT specification. In support of this amendment, Applicants submit herewith a declaration showing that the amended paragraph beginning on page 62, line 2 is a true and correct translation of the corresponding portion of the original Japanese PCT specification.

Moreover, the value "59 %" appearing at page 63, line 10 has been corrected to --49 %--. This amendment is apparent from the context containing the corrected portion. Specifically, attention

is drawn to the description at page 63, lines 10 to 14, which reads as follows:

> *Then, there was provided titanium expanded metal 2 having an opening area ratio of about ~~59~~ 49 % and a thickness of 1 mm (wherein titanium expanded metal 2 was a perforated plate having rhombic openings at a density of 35 openings relative to 10 $cm^2$, wherein each opening had a vertical diagonal length of 4 mm and a horizontal diagonal length of 7 mm) (underlining means the instantly amended portions).*

Based on the values in the above-quoted description, the correct opening area ratio (49 %) of the titanium expanded metal 2 can be obtained as follows.

Calculation of the area of rhombic opening

The area of a rhombus is calculated by the following formula: Area of rhombus = (vertical diagonal length) × (horizontal diagonal length) × 0.5.

By applying the values of the vertical diagonal length and horizontal diagonal length, which are shown in the above-quoted description of the present specification, to the above-mentioned formula, the area of the rhombic opening can be calculated:

Area of rhombic opening = 4 × 7 × 0.5 = 14 ($mm^2$).

Calculation of the opening area ratio

Using the value obtained above, the opening area ratio can calculated by the following formula:

Opening area ratio (%)

= (area of opening) × (opening density) × 100.

As is apparent from the above-quoted description, in the titanium expanded metal 2 in the above-quoted description of the present specification, 35 openings are present relative to 10 $cm^2$. Accordingly, the opening density is calculated as follows (in the following calculation, the value "10 $cm^2$" is converted to 1000 $mm^2$ so as to use the same units ($mm^2$) as used for the area of opening calculated above):

Opening density = (number of openings)/(unit area)

= 35 openings/1000 $mm^2$

By applying the calculated values of the area of opening and opening density to the above-mentioned formula, the opening area ratio can be calculated:

Opening area ratio

= 14 $mm^2$ × (35 openings/1000 $mm^2$) × 100 = 49 (%).

From the above, it is apparent that the value "59 %" appearing at page 63, line 10 should correctly read --49 %--.

**Rejections under 35 USC §103**

Claim 1 has been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of Kimura '390 (U.S. Patent No. 5,571,390).

Claims 2 and 3 have been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of Kimura '390 (US Patent No. 5,571,390) as applied to claim 1, and further in view of Iacopetti '670 (WO 98/55670).

Claim 4 has been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of Kimura '390 (US 5,571,390) as applied to claim 1, and further in view of Fuseya '953 (US 4,295,953).

These rejections are traversed for the following reasons.

**Present Invention**

Before specifically addressing the rejection of the claims over the references, it is believed that the following background information should be considered in order to shed proper light on the development of the present invention and the advantageous features thereof.

As discussed in the specification under "Prior Art", for stably performing electrolysis of an alkali metal chloride to produce low-cost chlorine, hydrogen and an alkali metal hydroxide,

it is required that the cost of equipment be low, that the electrolytic voltage be low, that vibrations in the electrolytic cell do not cause breakage of the ion exchange membrane, and that the concentration distribution of the electrolytic solution in the electrode compartment be narrow. If these factors are achieved, the voltage and the current efficiency of an ion exchange membrane remain stable for prolonged periods of time.

In recent years, in accordance with these desired features, remarkable progress has been made in technology for the electrolysis of an alkali metal chloride using an ion exchange membrane (*i.e.*, the technology for ion exchange membrane electrolysis) as described at page 4, lines 3 to 15 of the present specification. However, recently there has been a strong desire to increase the size of the equipment for performing electrolysis, to save energy, and to increase efficiency. In addition, it has also been desired that electrolysis be able to be performed at current densities as high as 50 $A/dm^2$ or more, which are far higher than the maximal current density (30 $A/dm^2$) which was possible at the time of the introduction of the instant ion exchange membrane electrolysis method. Applicants point out that the higher the current density, the smaller the number of electrolytic cells needed, *i.e.*, the lower the equipment cost. In other words, the

cost of equipment can be decreased when electrolysis can be performed at higher current densities.

However, when electrolysis is performed at a high current density, the amount of gas formed increases, causing an increase in the pressure fluctuations in the electrolytic cell, so that vibrations are likely to be generated in the electrolytic cell. When electrolysis at a high current density was performed for extended periods of time, the prior art suffered from problems caused by excessive vibration in the electrolytic cell, such as ion exchange membrane breakage.

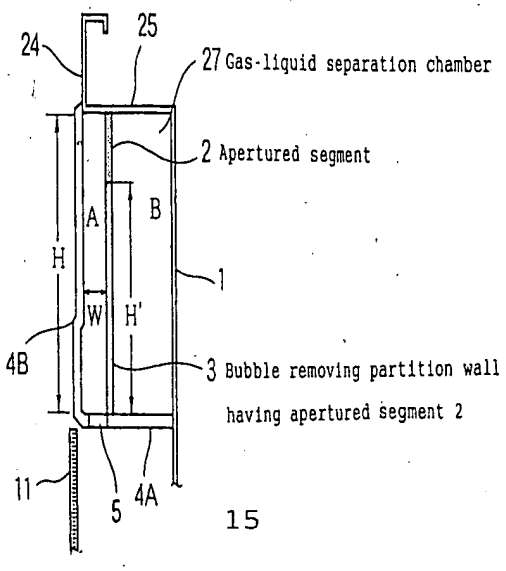
Conventionally, many proposals have been made with respect to the unit cell for the ion exchange membrane electrolysis of an alkali metal chloride, in which a high purity alkali metal hydroxide can be produced at a high current density. However, until the instant invention, such a unit cell had not been developed (see page 6, line 15 to page 10, line 21 of the present specification for this description).

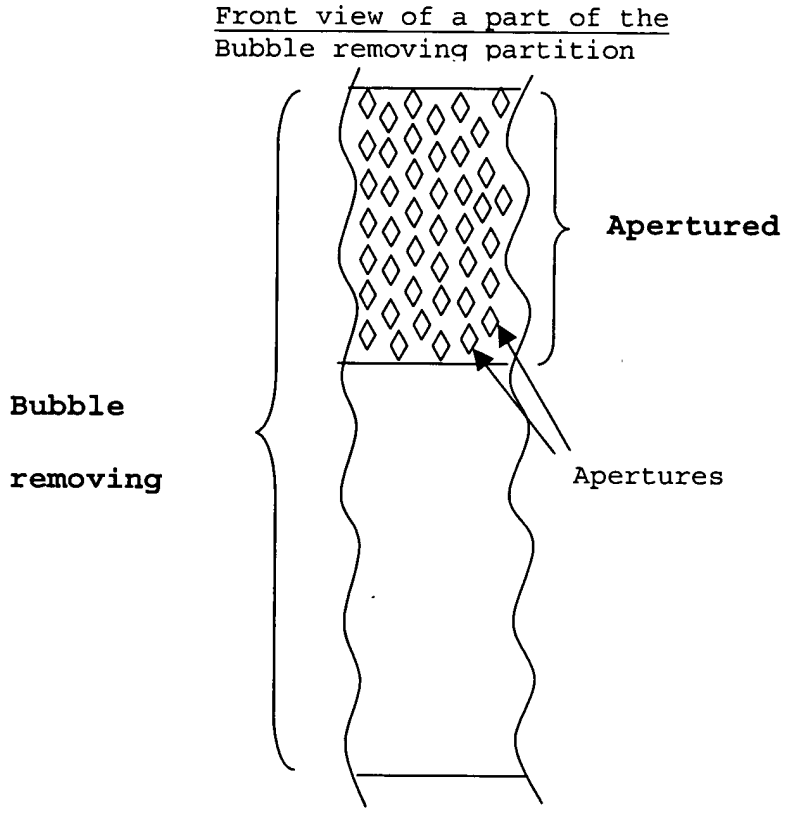
Keeping this in mind, the present inventors have made extensive and intensive studies with a view toward developing a unit cell for use in a bipolar, filter press type electrolytic cell used for performing ion exchange membrane electrolysis. This unit cell is advantageous in that a gas and an electrolytic solution can be discharged when the gas and the electrolytic solution are

substantially completely separated from each other, so that, even when the electrolysis is performed at a current density as high as $50A/dm^2$ or more, the occurrence of vibrations in the cell are prevented, thus preventing breakage of the ion exchange membrane. As a result, it has surprisingly been found that the discharge of a gas and a liquid in a substantially completely gas-liquid separated condition can be achieved by the use of a unit cell as defined in instantly amended claim 1 of the present application.

Accordingly, the characteristic feature of the unit cell of the present invention resides in the use of a gas-liquid separation chamber having a specific structure. For example, the gas-liquid separation chamber used in the unit cell assembled in Example 1 of the present application has the structure shown in Fig. 2 of the present application. For easy reference, Fig. 2 of the present application is reproduced below. Comments have been added to explain this figure.

FIG.2






As can be seen from instantly amended claim 1 of the present application, the gas-liquid separation chamber used in the unit cell of the present invention has a bubble removing partition wall having an apertured segment, wherein the aperture ratio of the apertured segment (based on the area of the apertured segment) is in the range of from 30 to 70 % and the average area of the apertures of the apertured segment is in the range of from 3 to 60 $mm^2$. In the present invention, the above-mentioned specific aperture ratio and average aperture area are features that suppress

the occurrence of vibrations in the electrolytic cell even when the electrolytic cell is operated at current densities as high as 50A/$dm^2$ or more. This prevents the occurrence of the adverse effects of vibrations, such as the breakage of the ion exchange membrane. In order to substantiate this, the Applicants have instantly performed experiments to evaluate the influences of the aperture ratio and average aperture area of the apertured segment of a bubble removing partition wall on the occurrence of vibrations in an electrolytic cell. The method and results of the experiments are as described in Exhibit 1 of the accompanying 37 CFR §1.132 declaration executed by Mr. Noaki, one of the inventors of the instant application.

Specifically, in Exhibit 1 of the accompanying declaration, bipolar, filter press type electrolytic cells (*i.e.*, cells 1 to 4 using the unit cells of the present invention and comparative cells 1 to 5) were assembled in substantially the same manner as in Example 1 of the present application (described at page 61, line 7 to page 69, line 4 of the present specification) except that the aperture ratio of the apertured segment and the average area of the apertures of the apertured segment were varied as shown in Table A below. Using each of the assembled electrolytic cells, electrolysis was performed at a current density of 60 A/$dm^2$ in the same manner as in Example 1 of the present application, and the

vibrations in the electrolytic cell were determined in the same manner as in Example 1 of the present application.

Further, with respect to each of the electrolytic cells obtained in Example 1 of the present application and cells 1 to 4 (using the unit cells of the present invention), electrolysis was also performed at a current density of 80 A/dm$^2$, and the vibrations in the electrolytic cell were determined.

Table A

| Electrolytic cell | | Aperture ratio of apertured segment (%) | Average area of apertures (mm$^2$) |
|---|---|---|---|
| Present invention | Cell of Ex. 1 of the present application | **49** | **14.0** |
| | Cell 1 | **30** | **3.0** |
| | Cell 2 | **70** | **3.0** |
| | Cell 3 | **30** | **60.0** |
| | Cell 4 | **70** | **60.0** |
| Comparative | Comparative cell 1 | 20 | **3.0** |
| | Comparative cell 2 | 80 | **3.0** |
| | Comparative cell 3 | **30** | 2.0 |
| | Comparative cell 4 | **30** | 70.0 |
| | Comparative cell 5 | **70** | 70.0 |

Note: The values in boldfaced typing are values each of which is within the range defined in the present invention.

The results of the above experiments are shown in Table B below.

Table B

| | | Aperture ratio of apertured segment (%) | | | | |
|---|---|---|---|---|---|---|
| | | 20 | 30 | 49 | 70 | 80 |
| Average area of apertures ($mm^2$) | 2.0 | - | <Comp. cell 3> 60-110 $mmH_2O$ at 60 $A/dm^2$ | - | - | - |
| | 3.0 | <Comp. cell 1> 100-150 $mmH_2O$ at 60 $A/dm^2$ | **<Cell 1> Less than 50 $mmH_2O$** at 60 and 80 $A/dm^2$ | - | **<Cell 2> Less than 50 $mmH_2O$** at 60 and 80 $A/dm^2$ | <Comp. cell 2> 60-110 $mmH_2O$ at 60 $A/dm^2$ |
| | 14.0 | - | - | **<Ex. 1> Less than 50 $mmH_2O$** at 60 and 80 $A/dm^2$ | - | - |
| | 60.0 | - | **<Cell 3> Less than 50 $mmH_2O$** at 60 and 80 $A/dm^2$ | - | **<Cell 4> Less than 50 $mmH_2O$** at 60 and 80 $A/dm^2$ | - |
| | 70.0 | - | <Comp. cell 4> 120-170 $mmH_2O$ at 60 $A/dm^2$ | - | <Comp. cell 5> 100-150 $mmH_2O$ at 60 $A/dm^2$ | - |

Present Invention

Table B above shows:

1) that, in the case of the cell of Example 1 of the present application and cells 1 to 4 using the unit cells of the present invention, the vibrations in the electrolytic cell (in terms of the height of a water column) were advantageously small, *i.e.*, less than 50 mm $H_2O$, even at a current density as high as 80 $A/dm^2$, and

2) that, in contrast, in the case where either of the aperture ratio or the average aperture area was out of the respective ranges defined in claim 1 of the present application (*i.e.*, in the case of comparative cells 1 to 5), the vibrations in the electrolytic cell (in terms of the height of a water column) were disadvantageously high, *i.e.*, 60 mm $H_2O$ or more at 60 $A/dm^2$.

Therefore, it is apparent that both of the above-mentioned specific aperture ratio and average aperture area, which are defined in claim 1 of the present application are the features that suppress the occurrence of vibrations in the electrolytic cell even when the electrolytic cell is operated at current densities as high as 60 or 80 $A/dm^2$. These features thereby prevent the adverse effects of vibrations, such as the breakage of an ion exchange membrane.

**Disclosure of Kimura '390**

Kimura '390 discloses a bipolar type ion exchange membrane electrolytic cell that has gas-liquid separating chambers, which

minimizes the pressure fluctuation in compartment frame units, the deterioration of ion exchange membranes and the voltage variation in the compartment units. The upper portions of back plates are outwardly bent at a higher position than the meshed electrode plates of each of the anode and cathode compartment frames to form inverse U-shape portions. U-shaped channel members are respectively placed in and fixed to the inverse U-shape portions so that spaces are formed, as passages, in association with the back plates. The areas defined by the inverse U-shape portions and the U-shaped channel members are gas-liquid separating chambers.

**Disclosure of Fuseya '953**

Fuseya '953 discloses a filter-press type ion exchange membrane-method electrolysis cell comprising (a) an anode structure which comprises a rectangular anode frame including a top element, a bottom element and two side elements and anode plates welded to the anode frame, (b) a cathode structure which comprises a rectangular cathode frame including a top element, a bottom element and two side elements and cathode plates welded to the cathode frame, and (c) an ion exchange membrane interposed between the anode structure and the cathode structure. The two side elements of the anode frame and the two side elements of the cathode frame have a tubular structure with a rectangular cross section, the top and bottom elements of the anode frame and the top and bottom

elements of the cathode frame have a ]-shaped cross section, and are secured such that their open portions face the inside of an anode compartment and a cathode compartment, respectively. At least one end of the top element of the anode frame communicates with the top end of the side element of the anode frame and at least one end of the top element of the cathode frame communicates with the top end of the side element of the cathode frame so that the side element communicating with the top element of the anode frame, and the side element communicating with the top element of the cathode frame form conduits for withdrawing gas and solution flowing from the anode compartment and the cathode compartment, respectively. A current disperser surrounding an anode lead bar is welded to the anode plates within the anode structure and a current disperser surrounding a cathode lead bar is welded to cathode plates within the cathode structure. There also exists a region that does not permit the passage of a gas that is formed between the periphery of the anode lead bar and the inside of the current disperser welded to the anode plates and between the periphery of the cathode lead bar and the inside of the current disperser welded to the cathode plates. This serves as a passage for a downwardly moving stream of electrolytic solution. Finally, there is (e) a pipe for supplying an anolyte solution disposed within the anode compartment and a pipe for supplying a catholyte solution disposed within the cathode compartment.

**Disclosure of Iacopetti '670**

Iacopetti '670 discloses a design of elements for ion exchange membrane electrolyzers. The two sides of the ion exchange membrane electrolyzers are made of two sheets cold-pressed in order to obtain projections and a peripheral flange, which ensures sealing with a suitable gasket. In the case of chlor-alkali electrolysis, the two sheets are made of titanium and nickel. The projections are preferably in the form of a truncated cone and are preferably arranged according to a centered hexagonal configuration. This geometry is said to favor the transversal mixing of the electrolytes due to the deviation and local flow crossing. The electrolyte is fed to the element through a distributor provided with holes. The distributor is housed in the lower part of the element along the internal edge of the flange. The electrolyte and the produced gas mixture is forced to flow to the upper part of the elements by an inclined baffle, which provides for collapsing the gas bubbles. Fresh electrolyte is said to be efficiently mixed with the liquid coming from the downcomers.

**Removal of the Rejections over Applicant's Admission of Prior Art in view of Kimura '390, Iacopetti '670, and Fuseya '953**

Claim 1 has been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of

Kimura '390 (U.S. Patent No. 5,571,390). Specifically, the Examiner states as follows:

> *Kimura et al. teach an anode-side gas-liquid separation chamber and a cathode-side gas liquid separation chamber that includes a bubble removing partition wall (10a) extending upwardly from the bottom wall of the gas liquid separation chamber for the purpose of reducing pressure fluctuations. The wall 10a extends along the entire length of the gas-liquid separation chamber and thus partitions the chamber into a first passage A (located between wall 10a and walls 5 and 3a) and a second passage B (located between wall 10a and wall 10).*
>
> *The partition wall 10a has an apertured segment 14, which allows for communication between passage A and passage B. While Kimura et al. fail to teach the height of the aperture, it would have been within the expected skill of a routineer in the art to have optimized the height of the wall to ensure proper minimization of pressure fluctuations.*
>
> *Therefore, it would have been obvious to one of ordinary skill in the art to have incorporated the partition wall of Kimura et al. into the admitted apparatus because the partition wall of Kimura et al. has the effect of reducing pressure fluctuations thereby preventing the deterioration of the ion exchange membranes and reducing the voltage variation.*
>
> Applicants traverse.

Kimura '390 discloses a bipolar type ion exchange membrane cell having gas-liquid separating chambers, which minimizes the pressure fluctuation in compartment frame units, the deterioration of ion exchange membranes and a voltage variation in the compartment units. However, Kimura '390 has no teaching or suggestion about the elements as claimed in claim 1, such as the above-mentioned specific aperture ratio and average aperture area

for suppressing the occurrence of vibrations in the electrolytic cell even when the electrolytic cell is operated at a high current density (*e.g.*, 60 or 80 $A/dm^2$). This feature of the instant invention thereby prevents the occurrence of any adverse effects of vibrations, such as the breakage of an ion exchange membrane. A more detailed explanation is given below.

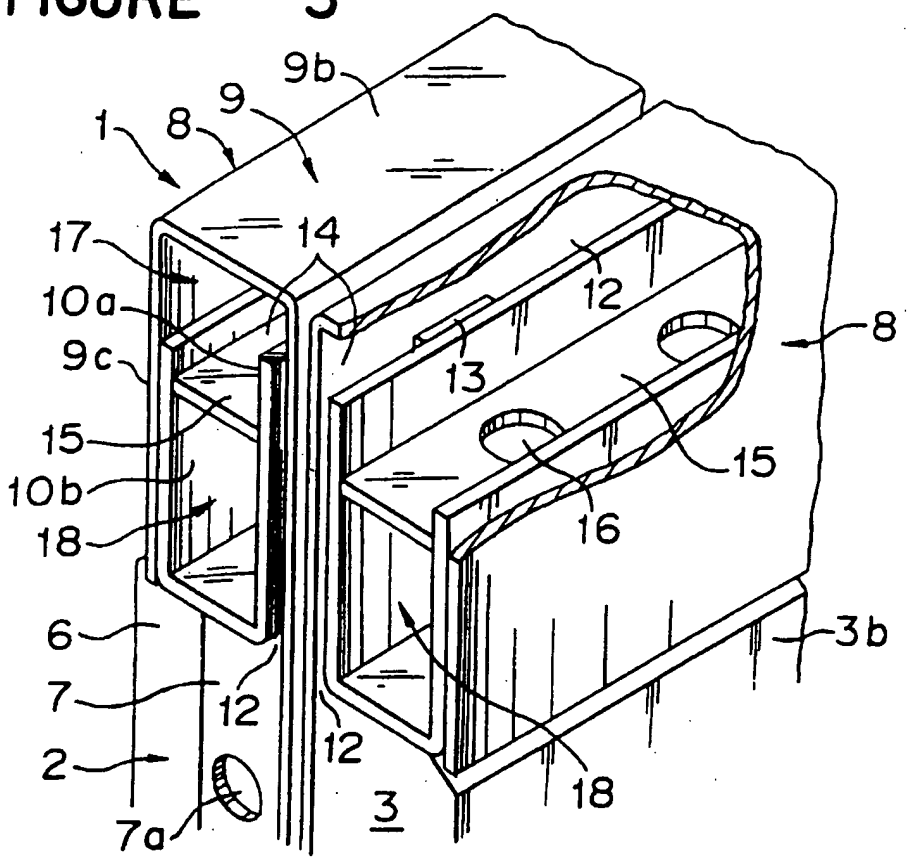
First, Applicants refer to the figures in Kimura '390, wherein it should be noted that portion 14 of the unit cell of Kimura '390 is not an "apertured segment" as defined in the present invention. As apparent from instantly amended claim 1, the "apertured segment" of the bubble removing partition wall is a segment having a plurality of apertures. In the present invention, the term "apertures" means "holes" as apparent from the following description of the present specification.

> *With respect to the distribution of apertures in apertured segment 2, there is no particular limitation so long as the bubble removal can be conducted efficiently. However, it is preferred that the distribution of apertures is as uniform as possible. As specific examples of manners of forming apertures, there can be mentioned a manner in which nineteen (19) circular apertures, each having a diameter of 2 mm, are formed at a pitch of 3 mm, per 1 cm2 of apertured segment 2, and a manner in which thirty five (35) rhombic apertures, each having diagonal lines of 7 mm and 4 mm, are formed, per 10 cm2 of apertured segment 2. (emphasis added) (see page 41, lines 5-16 of the present specification)*

In contrast, portion 14 of the unit cell of Kimura '390 is only a "gap" which is "formed as inlet 14 for introducing the gas-liquid

mixture phase stream going up through the passage 12 into the gas-liquid separating chamber, formed by the upper end of the inner side portion 9b of the outer frame 9" (see column 4, lines 45-50 of Kimura '390). This is also apparent from of Kimura '390. For easy reference, FIGURE 3 of Kimura '390 is reproduced below.

FIGURE 3




Apart from the above, as can be seen from FIGURE 3 of Kimura '390, the unit cell of the Kimura '390 has a "holding member 15" which has apertures 16. However, Kimura '390 has no description about the aperture ratio and the average aperture area of the

"holding member 15". Further, it should be noted that in the Working Examples of Kimura '390, the aperture ratio and average aperture area of the "holding member 15" are outside the ranges claimed in instantly amended claim 1. Specifically, in the unit cell used in each of the Working Examples of Kimura '390, 24 apertures each having a diameter of 12 mm (*i.e.*, a radius of 6 mm) are formed in the holding member 15 (see col. 6, lines 20-21 of Kimura '390). The area of each aperture can be calculated as follows:

Area of aperture = $r^2\pi = 6 \times 6 \times \pi = 113$ ($mm^2$).

Further, from the size ("240 cm wide and 120 cm high" described at col. 5, line 61 of Kimura '390) of the electrode plate 3b or 6 (shown in FIGURE 3 of Kimura '390) and the size ("a thickness of 2.0 mm and a width of 30 mm" as described at col. 5, lines 66-67 of Kimura '390) of each of the supporting members 7 (shown in FIGURE 3 of Kimura '390), it can be estimated that holding member 15 has a width of 28 mm and a length of 2400 mm. Thus, the aperture ratio of holding member 15 (based on the area of holding member 15) can be calculated as follows:

Aperture ratio = 113 ($mm^2$) × 24 / (28 mm × 2400 mm) ×100 = 4 (%)

Thus, the aperture ratio and average aperture area of each of the unit cells used in the Working Examples of Kimura '390 are outside the respective ranges (*i.e.*, aperture ratio = 30 to 70 %, and average aperture area = 3 to 60 $mm^2$) defined in instantly

amended claim 1. As was mentioned above with reference to the 37 CFR §1.132 Declaration, both the above-mentioned specific aperture ratio and average aperture area which are defined in claim 1 of the present application are features that suppress the occurrence of vibrations in the electrolytic cell even when the electrolytic cell is operated at a current density as high as 60 or 80 $A/dm^2$. As also mentioned above, this prevents the occurrence of adverse effects from vibrations, such as the breakage of an ion exchange membrane.

From the above, it is apparent that the unit cell as defined in claim 1 of the present application is patentably distinct from the unit cell used in Kimura '390. Accordingly, the rejection is inapposite. Withdrawal of the rejection is warranted and respectfully requested.

Further, claims 2 and 3 have been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of Kimura '390 (US 5,571,390) as applied to claim 1, and further in view of Iacopetti '670 (WO 98/55670). Moreover, claim 4 has been rejected under 35 USC 103(a) as being unpatentable over Applicant's admission of prior art in view of Kimura '390 (US 5,571,390) as applied to claim 1, and further in view of Fuseya '953 (US 4,295,953).

However, claims 2 to 4 are dependent from claim 1. Because none of the cited reference has any teaching or suggestion about

the above-mentioned specific aperture ratio and the average aperture area, Iacopetti '670 and Fuseya '953 fail to make up the deficiencies present in Kimura '390. Thus, it is apparent that each of claims 2 to 4 should be patentable over any combination of the cited references. The rejections are inapposite. Withdrawal of the rejections is warranted and respectfully requested.

With the above remarks and amendments, it is believed that the claims, as they now stand, define patentable subject matter such that passage of the instant invention to allowance is warranted. A Notice to that effect is earnestly solicited.

If any questions remain regarding the above matters, please contact Applicant's representative, T. Benjamin Schroeder (Reg. No. 50,990), in the Washington metropolitan area at the phone number listed below.

Pursuant to the provisions of 37 C.F.R. §§ 1.17 and 1.136(a), Applicants respectfully petition for a two (2) month extension of time for filing a response in connection with the present application. The required fee of $420.00 is attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

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0216-0462P

Attachment(s): Declaration regarding translation
Declaration under 37 CFR § 1.132

(Rev. 09/30/03)